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(12) UK Patent Application (19) GB (11) 2 386 517 (13) A

(43) Date of A Publication 17.09.2003

(21) Application No 0314168.6

(22) Date of Filing 29.01.2002

Date Lodged 18.06.2003

(30) Priority Data

(31) 0102261 (32) 29.01.2001 (33) GB

(62) Divided from Application No

0202030.3 under Section 15(4) of the Patents Act 1977

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(74) continued overleaf

(51) INT CL⁷

H04L 12/56, H04M 1/725

(52) UK CL (Edition V)

H4L LDGP

H4P PENX

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(54) Abstract Title

Enhanced cordless telephone platform using the Bluetooth protocol

(57) A method for transmitting a digitally encoded audio signal (e.g. voice) from a first wireless device 600 having a transmitter 730 to a second wireless device 610 via a Bluetooth asynchronous connectionless link (ACL) 700 comprising: receiving a first portion of encoded audio at the transmitter of the first wireless device; generating an error detection code derived from the first portion of encoded audio; generating a data packet having a first payload comprised of the first portion of encoded audio and the error detection code; transmitting the data packet from the first device to the second device via the ACL; flushing the ACL approximately when the first device transmitter receives a second portion of the encoded audio for transmission to the second wireless device. The data packet may have the structure of a DM3 packet (which is a packet not normally used for voice communication). The method may further comprise detecting that the data packet was received without error at the second wireless device and (i) generating an analog audio signal 770 if the payload received does not contain errors or (ii) muting the audio signal if the payload received contains errors. Furthermore the data packet may be repeatedly transmitted by the first device until an acknowledge signal is received from the second device or until the asynchronous connectionless link is flushed. Furthermore the data packet may comprise (a) information indicative of the technique used to encode the audio signal, (b) an auxiliary data field which may contain information such as caller identification (caller ID) information.

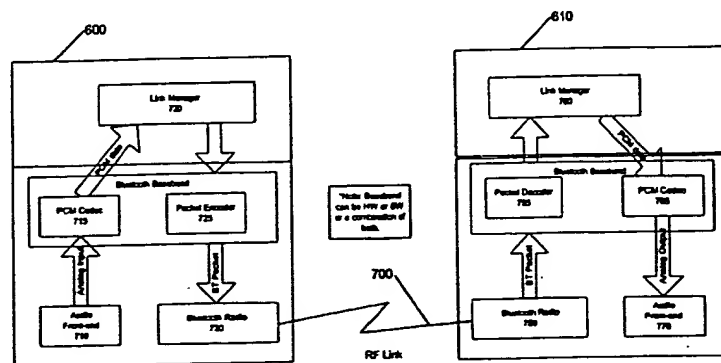


Figure 7

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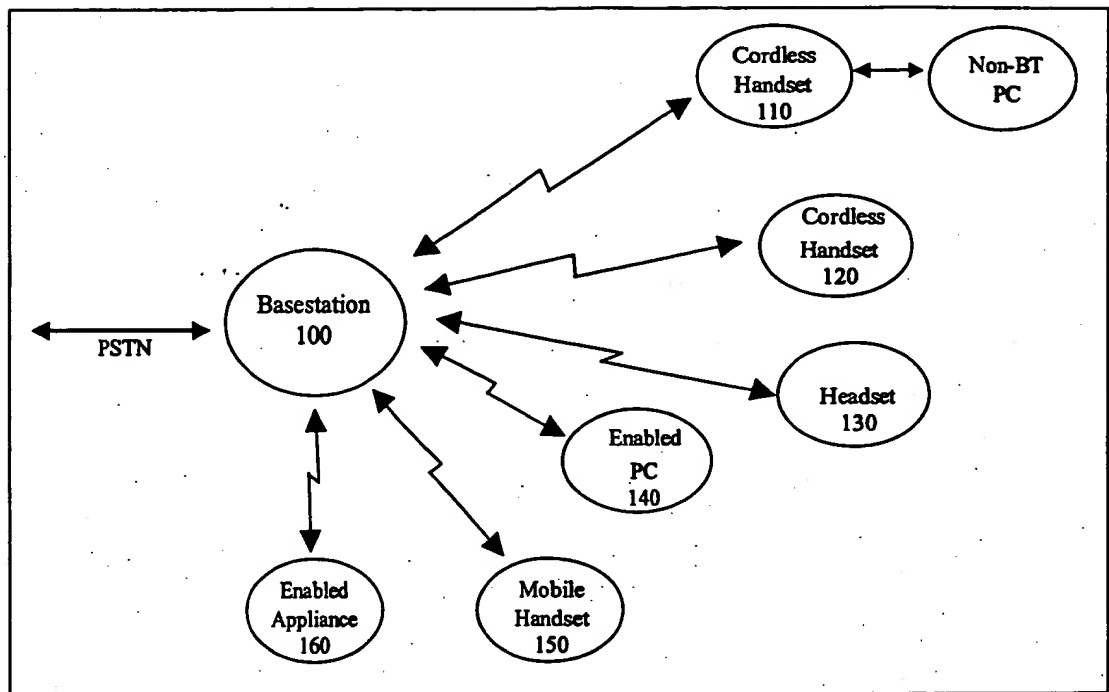


Figure 1

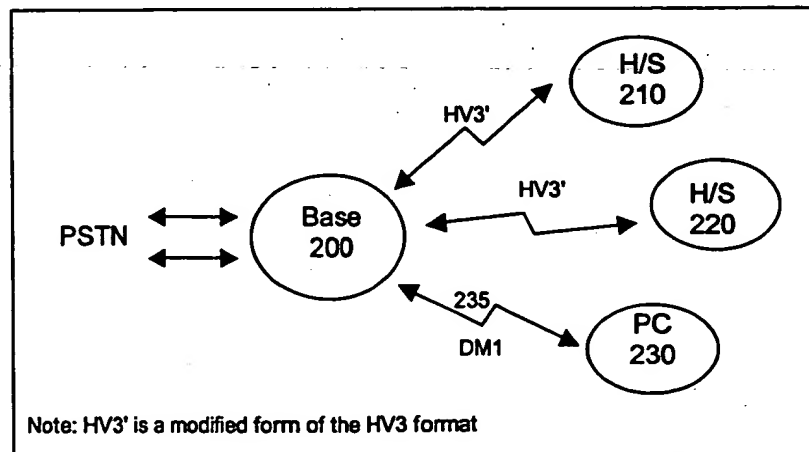


Figure 2

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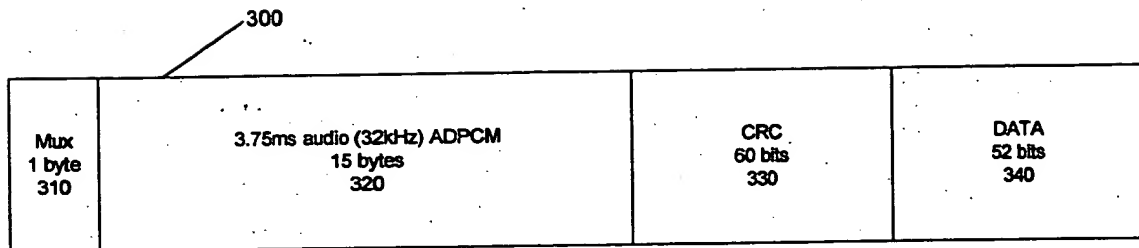


Figure 3

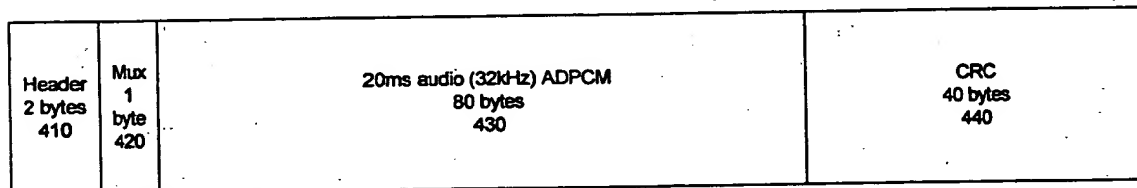


Figure 4

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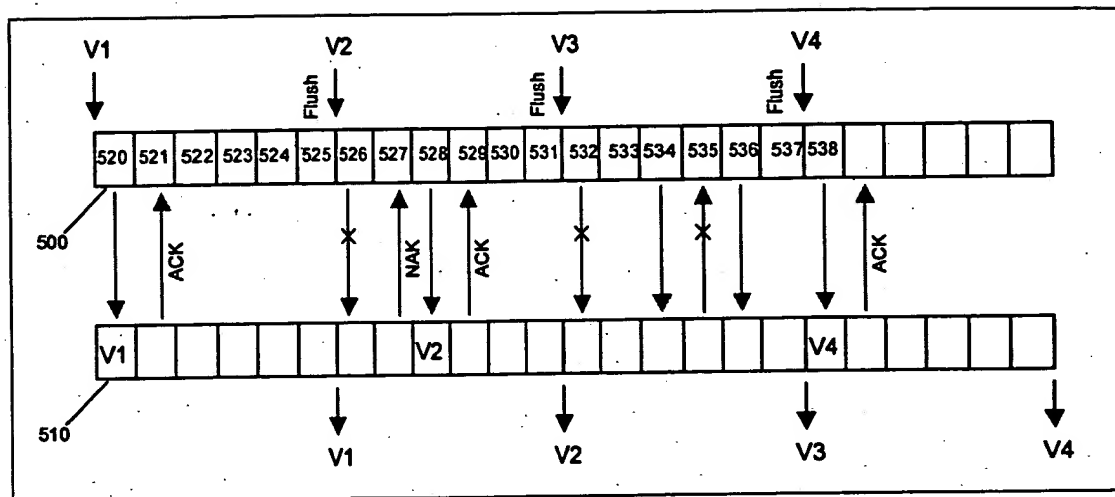


Figure 5

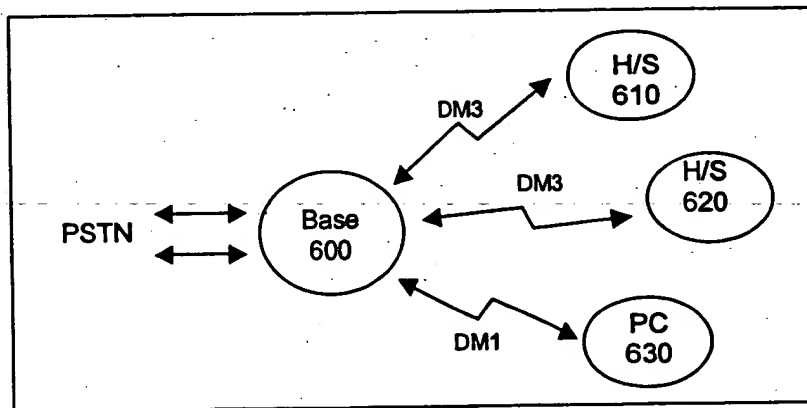


Figure 6

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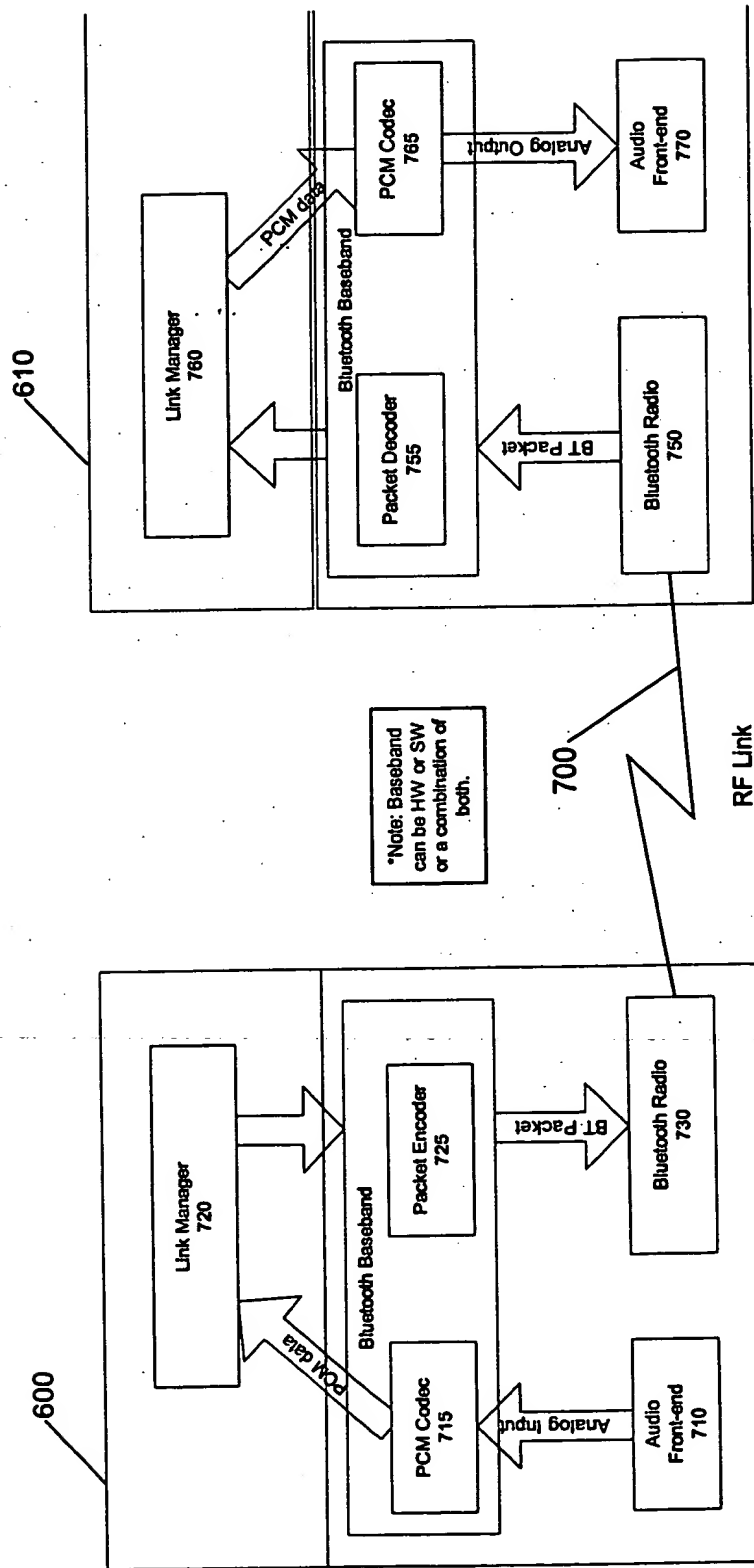


Figure 7

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ENHANCED CORDLESS TELEPHONE PLATFORM**BACKGROUND OF THE INVENTION****1. Field of the Invention**

This invention relates in general to a cordless telephone system. In particular, the invention relates to the implementation of a cordless telephone system using the Bluetooth wireless digital communications standard.

2. Background Art

Bluetooth is an emerging wireless standard, operating in the 2.4GHz ISM band world-wide. Although originally developed for use in the mobile phone industry, widespread adoption within the consumer electronics industry suggests that it is likely to become a popular and commonplace home wireless standard in the coming years. Due to its predicted penetration into the consumer market, it is of considerable interest to use the Bluetooth standard as the bearer for a cordless telephone system.

In its basic form, a cordless system consists of a basestation that is connected to the Public Switched Telephone Network ("PSTN") and that communicates wirelessly to a handset. The principal channel between the basestation and handset is voice data (the telephone call), although there is typically also a small amount of control data and information to be exchanged. The system can be (and has been) extended to multiple PSTN connections and multiple handsets.

Several characteristics for a wireless communications link may be desirable in implementing a cordless telephony platform. Such characteristics include: 1) the

provision of at least two full-duplex voice links to support multiple handsets; 2) a low-speed data link in parallel with voice links for system communication such as caller ID information; 3) a high-speed data link to provide for transmission of call setup information with minimal delay; 4) robust error detection and/or error correction on voice and data links to ensure high-quality and uninterrupted communications; and 5) implementation of one or more high speed data links in parallel with the voice link(s).

However, the transmission formats defined by the Bluetooth specification do not provide a combination of these characteristics that is typically desirable for cordless telephony. Three Synchronous Connection-Oriented ("SCO") packet types are defined in the Bluetooth standard specifically for voice transmission (namely, HV1, HV2 and HV3). A SCO link is a point-to-point, circuit-switched connection between a master and a slave. The Bluetooth SCO links employ varying error correction schemes where Forward Error Correction ("FEC") may or may not be available to protect the transmitted data. HV1 uses 1/3 rate FEC and allows 10 bytes of data; HV2 uses 2/3 rate FEC and allows 20 bytes of data; and HV3 uses no FEC and allows 30 bytes of data. The packet header is always protected by 1/3 rate FEC.

Bluetooth's HV1 format occupies the complete channel bandwidth for a single link, and is thus unable to support multiple handsets or a parallel data channel. In contrast, the HV3 link occupies a reduced bandwidth but does not contain error detection which is required for implementation of a high-quality voice link. The HV2 format allows two full-duplex voice links but lacks desirable parallel data capability. Such parallel data capabilities may be a primary motivation for moving to a Bluetooth wireless bearer. Furthermore, even Bluetooth's voice links which provide error

correction do not provide error detection. Therefore, packets with errors that are not properly corrected cannot be readily muted, potentially exposing the data recipient to unpleasant audible noise.

Thus, the voice formats defined by the Bluetooth standard are unsatisfactory for many advanced cordless telephone applications. However, if the limitations of the formats could be overcome, it would be desirable to implement a Bluetooth-based cordless telephone system so that the base unit can also serve as a Bluetooth gateway, thereby enabling advanced communications with a variety of electronic devices with minimal added expense.

SUMMARY OF THE INVENTION

A technique for transmitting voice data via a Bluetooth communications link is presented

An asynchronous Bluetooth link can be implemented
5 to provide improved error detection capabilities,
parallel data communications and/or a greater number of
simultaneous cordless telephone links. The asynchronous
link packet payloads are formed including digitized audio
data and various other information. Each packet is then
10 transmitted. Transmissions can be repeated on subsequent
time slots if an acknowledgement is not received, or if
the link is flushed. The link is flushed each time new
digitized audio data is presented for transmission.

A synchronous Bluetooth link can also be
15 implemented to provide improved error detection
capabilities and/or parallel data communications
capabilities. The audio data is encoded at a bitrate less
than that specified for the synchronous link. The link
packet payload is then encoded to comprise the audio data
20 and an error detection field. A parallel data channel may
also be encoded within the packet payload. Upon receipt
of the packet by a second device, the packet payload is
decoded and the digitized audio data is extracted and
verified.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram of a cordless telephony system based upon a base station serving as a Bluetooth gateway for communication with a variety of Bluetooth-enabled devices.

Figure 2 is a Bluetooth-based cordless telephone system using modified HV3 links for telephonic communications.

Figure 3 is an embodiment of an HV3 data packet modified for telephonic applications.

Figure 4 is an embodiment of a DM3 data packet with payload adapted for telephonic communications.

Figure 5 is a chart illustrating transmissions over time of a cordless telephone voice data using an asynchronous Bluetooth data link.

Figure 6 illustrates a cordless telephone system using asynchronous Bluetooth data links for voice transmission.

Figure 7 is a functional block diagram of a voice communications path from a cordless telephone base station to a handset.

DETAILED DESCRIPTION OF AN EMBODIMENT

One advantage of using the Bluetooth standard as a wireless bearer is to additionally allow the wireless communication of data (as opposed to voice) between the base station and various data terminals. In this context, the base station would be termed a gateway. An example embodiment of this type of system including cordless telephone functionality is shown in Figure 1. The system of Figure 1 implements a proprietary link based upon the Bluetooth air interface for communications between gateway 100 and cordless telephony devices such as handsets 110 and 120 or cordless telephone headset 130. However, gateway 100 is likewise fully capable of communicating via conventional Bluetooth links with other Bluetooth-enabled devices, such as personal computer 140, mobile phone handset 150 or Bluetooth-enabled appliance 160.

In the embodiment of Figure 1, base station 100 is provided with the capability of querying other Bluetooth-based devices to determine which, if any, available devices are capable of communicating via an appropriate proprietary extension of the Bluetooth protocol. In addition, any Bluetooth-based devices may be provided with the capability of querying the base station 100 to determine if it is capable of communicating using a non-standard link that is derived from a Bluetooth Synchronous Connection-Oriented communications link. One mechanism that can be used to implement such a query is the Service Discovery Protocol ("SDP") defined under the Bluetooth protocol set. This mechanism allows for identifying the specific classes of service that are available for use. SDP

further allows for the retrieval of attributes that are needed to connect to a chosen service. Thus, attributes required to defined proprietary services can be configured and communicated using SDP.

For significant multi-handset capabilities under the standard Bluetooth specifications, the HV3 structure could be used. As defined by Bluetooth, the HV3 structure allows up to three full-duplex voice links to be established. However, the Bluetooth specification provides no error detection or correction on HV3 voice data. This is a serious disadvantage for a voice system since it will not be possible to mute the audio during periods of bad interference. As a result, the users may be subjected to harsh and annoying audible noise when communication errors occur.

The HV2 format defined by Bluetooth allows for two active duplex links with error correction and thus is another potential format for use in a cordless system. However, one disadvantage of using HV2 is that, if both voice links are active, there is no bandwidth available for parallel data, thus impairing the functionality of the cordless telephone system. A fully-functional HV2-based system would be possible if it was restricted to one active handset plus data. While additional handsets could be provided, only one could be active at one time. Furthermore, while HV2 provides for error correction, it does not provide for error detection. Thus, when the provided FEC capabilities are insufficient to correct an error, erroneous data is processed, potentially subjecting the user to hard and annoying audible noise.

The specifications of the Bluetooth standard can be augmented to overcome such drawbacks and to implement a fully-functional multi-handset cordless telephone system using the Bluetooth standard as the wireless bearer. Moreover, by

implementing the augmentations as proprietary extensions for communicating with proprietary handsets, the base unit remains free to engage in communications with other non-proprietary Bluetooth-enabled devices, serving as a Bluetooth gateway, with minimal extra cost or complexity of design.

One of the key issues with using a standard Bluetooth format for a cordless system is the number of active voice channels that can be supported. As explained above, the number of cordless channels using the standard formats is effectively limited to two (with no bandwidth remaining for an independent data channel) or one (with enough bandwidth remaining to support an independent data channel). However, multiple-handset telephone systems are becoming increasingly popular and desirable. Therefore, an increase in the number of channels that can be supported with high-quality links and full-featured communications capabilities is of great importance.

Figure 2 illustrates another embodiment of a cordless telephone system in which base station 200 serves as a gateway to communicate with conventional Bluetooth-enabled devices such as personal computer 230, which simultaneously being capable of communications with cordless telephone handsets 210 and 220 using a proprietary extension of a standard Bluetooth HV3 link, such as a link comprised of HV3 packets with altered payload structures.

Figure 3 illustrates such an altered HV3 payload structure according to one possible embodiment of the invention, which can be used in communications between base station 200 and cordless handsets 210 and 220. The HV3 packet structure is maintained, but the traffic contained within it is further encoded. HV3 normally provides 240 payload bits per packet with no error correction or detection. A compliant Bluetooth

system must support 64 kb/s CVSD (Continuous Variable Slope Delta) Modulation for encoding of audible information, and may also support 64 kb/s log PCM format (A-law or μ -law), Implemented with 64 kb/s voice coding according to the Bluetooth specification. Using the specified voice encoders, an HV3 packet transports 3.75ms of speech and HV3 can support up to 3 duplex voice links. However, the lack of data capacity and error detection makes HV3 only marginally useful in a cordless system.

Therefore, the modified HV3 payload structure of Figure 3 includes voice data field 320 which contains audible information encoded at 32 kbps using an ADPCM format. This format provides sufficient audio quality for high-quality telephonic communications. By using this proprietary voice encoding, the modified HV3 payload structure contains the same 3.75 ms of speech information contained within a standard HV3 packet, while requiring only 120 of the 240 HV3 payload bits. Therefore, further data fields can be encoded into the HV3 payload to provide improved cordless telephone functionality. It is further understood that other voice encoding techniques which reduce the audio bitrate below that implemented in a standard HV3 link can be utilized as well, such as reduced-rate CVSD modulation or audio compression algorithms. Generally speaking, lower bitrate audio encoding techniques provide greater bandwidth within payload 300 for encoding of other types of information.

In the payload structure of Figure 3, field 310 provides one byte of mux information, such as information specifying the voice data compression algorithm and/or other proprietary formatting information. Error detection/correction field 330 contains 60 bits of CRC information for the audio data contained in field 320. Unlike the FEC provided by Bluetooth, CRC field 330 allows some errors to be corrected, and

further allows for uncorrectable errors to be detected such that erroneous audio information can be appropriately muted. Finally, 52-bit field 340 provides for a low-rate data channel which can be used for features such as the transmission of caller identification information.

The system of Figure 2 can support up to three active links. Because the basic HV3 packet structure is maintained, the links may be any combination of proprietary voice links with payload structures such as that Figure 3, and conventional communications pursuant to the Bluetooth specification, such as data link 235 between base station 200 and personal computer 230.

In another embodiment of the invention, voice data can be transmitted using the Bluetooth data format links, rather than using the Bluetooth voice format links. By using data links, the transmission format can essentially be redefined completely. Figure 4 illustrates one possible payload structure of an embodiment of the invention based upon a DM3 link. Field 410 provides two bytes for a header. As in the payload structure of Figure 3, a one-byte multiplex field is provided by field 420. Audio field 430 contains 80 bytes of encoded voice data, which corresponds to 20 ms of audio information when encoded using a 32 kbps ADPCM format. Finally, error detection/correct field 440 contains 40 bytes of CRC information which can be used to correct and/or detect errors imposed during transmission of the payload. As with the payload structure of Figure 3, the payload structure of Figure 4 could readily include voice data encoded using other techniques, (i.e. at other bitrates and using other algorithms), and a parallel data channel could

readily be defined over the same DM3 link by including allocation for data within the payload structure of Figure 4.

However, the non-voice Bluetooth data links such as DM3 are normally asynchronous communication links (sometimes referred to as an Asynchronous Connection-Less ("ACL") link). Asynchronous links are typically undesirable for voice communications because of the timeliness required of the voice data transmission. Inasmuch as the normal operation of the ACL link is asynchronous, the recipient device automatically generates an ACK or NAK acknowledgment return signal to signify successful or unsuccessful reception of each data packet. The sender then retransmits the data unless and until an ACK signal is returned to the sender. However, for telephonic communications, voice data should preferably be transmitted and reproduced in near real time to enable efficient and natural conversation. Thus, only a certain limited amount of retransmission is allowable until the next voice data frame must be sent.

An embodiment of the system, implementing a DM3 link with the payload structure illustrated in Figure 5 for voice communications, can overcome the problems of an asynchronous data format by forcing the format to behave in a somewhat synchronous manner. This can be achieved by using a mechanism within the Bluetooth specification known as isochronous data transmission, which limits the automatic retransmission of data. The mechanism uses a "flush" command to prevent retransmission of data after a certain period of time has elapsed even if an ACK has not been received.

By using the flush mechanism in conjunction with a DM3 link with the payload structure of Figure 4, the voice communications link can also gain the benefit of time and frequency diversity for increased robustness and reliability. The automatic retransmission of voice data occurs according to the ACK/NAK protocol until the data channel is flushed. The system can be configured to flush the data channel upon receipt of each new frame of audio data by the transmitting interface. Thus, the transmitter always sends new voice data immediately upon receipt, resulting in prompt transmission of the audio signal. Any retransmissions of already-sent data that take place prior to the flushing of the channel occur at a different time from the initial transmission, and also at a different carrier frequency since Bluetooth is a frequency-hopping standard, thereby providing frequency and time diversity to further improve the reliability and robustness of the communication system.

The operation of this system is illustrated in Figure 5 which shows the transmission of four voice data packets, labelled V1 through V4, over a poor link, such as might be encountered in the presence of high-level radiofrequency interference. Each box represents a new Bluetooth packet, proceeding in time from left to right, with row 500 representing the transmitting device and row 510 representing the receiving device. Because Bluetooth is based upon a frequency-hopping radio protocol, transmissions during each box occur on a radio carrier frequency which differs from the previous transmission. The number of possible re-transmissions before the next voice packet is available (and therefore before the data link is flushed) will typically depend upon the amount of data traffic in the system as a whole and the amount of voice data carried in each packet. Typically, the gateway or base station acts as the master and

accordingly prioritizes required data transmissions. If transmission of extraneous data traffic with other devices is given greater priority than retransmissions of voice data, then such extraneous traffic may reduce or eliminate the opportunities for data retransmissions before the link is flushed.

For example, in Figure 5, data packet V1 is transmitted and successfully received during period 520. Thus, the receiving unit acknowledges successful receipt during period 521, and both units idle during periods 522 through 525, thus conserving power. At period 525, new data is received by the transmitting unit, so the data link is flushed. Then, during period 526, data packet V2 is transmitted to the receiving unit. Due to interference, the received data fails to satisfy the error detection and/or correction mechanisms implemented within the data packet. Accordingly, the receiving unit responds with a NAK signal during period 527. The transmitting unit, discovering that packet V2 has not been properly received, retransmits packet V2 during period 528. The receiving unit receives V2, and responds with an ACK signal, such that both units idle during periods 530 and 531. At period 532, data packet V3 is transmitted. However, due to interference the packet is not received by the receiving unit. Accordingly, neither an ACK or NAK is sent back during period 533. The transmitting unit, pursuant to its data transmission protocol, automatically resends the data packet V3 during period 534. The transmission is successful, but the receiving unit's ACK response during period 535 is blocked. The transmitting unit, not having received an ACK for V3, makes a final attempt to transmit V3 during period 536. The data link is then flushed to ensure that V4 will be transmitted in a timely manner in period 538.

While the ACL link data packet payload of Figure 4 is based upon a DM3 link, it is understood that similar payloads could readily be derived for other known Bluetooth ACL types as well, such as DM1, DH1, DH3, DM5 or DH5. However, while larger packets such as DM5 or DH5 have a very large capacity for voice data, such packets may not be appropriate for many telephony applications due to latency in the audio path. Each segment of speech must be compressed into a data packet, transmitted, and expanded back into audible information before it is heard by the recipient. Thus, a delay comprised of at least approximately the period of speech contained in one packet (required for buffering of the raw audio data before compression, transmission, decompression and playback) is imposed upon the communications channel. Because the larger packets would contain comparatively lengthy periods of speech in each packet, the inherent delay in the communications channel may result in undesirable audible characteristics. Therefore, packet types such as DM3 (using either 64kb/s or 32kb/s voice encoding) or DH1 (using 32kb/s) may be effective for many cordless telephony applications.

For a cordless telephone system implemented using DM3 links and 64kb/s voice encoding with the payload structure of Figure 4, each DM3 packet holds 10ms of encoded voice data along with 40 bytes of CRC error detection/correction information. Thus, given the time slot period of Bluetooth, a packet would be needed in each direction every 16 slots to maintain an uninterrupted full-duplex audio link. Up to 2 full-duplex voice links could be provided on a Bluetooth bearer, with some capacity for other data links as well. For one active voice link, several retransmissions may be

possible if needed as a result of a NAK, while for two active voice links only one retransmission would be possible.

For a cordless telephone system implemented using DM3 links and 32kb/s voice encoding with the payload structure of Figure 4, each DM3 packet could hold 20ms of encoded voice data along with 40 bytes of CRC error detection/correction information. Thus, given the time slot period of Bluetooth, a packet would be needed in each direction every 32 slots. Up to 5 full-duplex voice links could be provided, with some capacity for other data links as well. Moreover, a number of packet retransmissions may be available, depending upon the number of active links in the system. It is believed that an audio latency of approximately 20ms, as is inherent in such a system, should be acceptable for a voice communication link.

One embodiment of a Bluetooth-based cordless telephony system using ACL links is illustrated in Figure 6. Base unit 600 communicates with cordless handsets 610 and 620 using DM3 links with the payload structure of Figure 4 for voice transmission. Furthermore, base unit 600 is capable of simultaneously communicating with a Bluetooth-enabled digital device such as personal computer 630 using a DM1 link.

Figure 7 is a functional block diagram of the downlink between base unit 600 and cordless handset 610 connected by DM3 link 700, whereby voice signals are transmitted from the PSTN to handset 610. An analog audio signal is receiving from the PSTN at audio front end 710, and conveyed to PCM codec 715 for digitization. The PCM voice data is then conveyed to link manager 720. Link manager 720 processes the audio information in accordance with the proprietary link type selected for the communication link. For example, in the illustrated example, link manager 720 may

determine and insert the CRC, mux and header fields. In a system where link 700 was a modified HV3 with a payload structure of Figure 3, then the link manager could also insert data content corresponding to the relevant traffic for parallel data channel 340.

Link manager 720 outputs encoded payload data to packet encoder 725. Packet encoder 725 performs the packet formatting according to the type of link upon which link 700 is based, such as inserting the packet header and the encoded payload data into their appropriate positions within the packet. The formed packet is then conveyed to Bluetooth radio unit 730, which transmits the information wirelessly via link 700.

Handset radio 750 receives the transmitted information and outputs the packet to packet decoder 755. Packet decoder 755 extricates the encoded payload information, which is then conveyed to handset link manager 760. Link manager 760 further extracts the encoded audio data from the encoded payload, and sends the audio data to PCM codec 765. Codec 765 converts the digital audio data into an analog audio signal and sends the signal to audio front-end 770, which may include a speaker positioned within the telephone handset. In this way, an audio signal can be conveyed between devices using a Bluetooth bearer, while implementing proprietary features capable of providing a more robust and full-featured cordless telephony solution.

The uplink from handset 610 to base station 600 operates analogously to the downlink illustrated in Figure 7. Furthermore, the functional block diagram of Figure 7 can be readily implemented to also implement the transmission of voice data using a link based upon a SCO Bluetooth link, such as that illustrated in Figures 2 and 3. It is further contemplated that the Bluetooth baseband operations can readily be implemented in hardware, software or a combination of both. Many other

configurations could be readily implemented in place of that of Figure 7 in which the actual handling of the encoded voice data is performed in higher layers.

The foregoing description and drawings merely explain and illustrate the invention and the invention is not limited thereto except insofar as the appended claims are so limited, inasmuch as those skilled in the art, having the present disclosure before them will be able to make modifications and variations therein without departing from the scope of the invention.

Claims

1. A method for transmitting a digitally encoded audio signal from a first wireless device having a transmitter to a second wireless device via an asynchronous connectionless link, which method comprises the steps of:

receiving a first portion of encoded audio signal at the transmitter of the first wireless device;

generating an error detection code derived from the first portion of encoded audio signal;

generating a data packet having a payload comprised of the first portion of encoded audio signal and the error detection code;

transmitting the data packet from the first device to the second device via the asynchronous connectionless link;

flushing the asynchronous connectionless link approximately when the first device transmitter receives a second portion of encoded audio signal for transmission to the second wireless device.

2. The method of claim 1, in which the data packet has the structure of a BLUETOOTH (RTM) DM3 packet containing the payload.

3. The method of claim 1, which method further comprises the steps of:

extracting the payload from the data packet by the second wireless device;

detecting whether the payload received contains errors by implementing an error detection protocol using the error detection code received within the payload;

generating an analog audio signal by the second device when the payload received does not contain errors, the analog audio signal being derived from the first portion of encoded audio signal;

muting the first portion of encoded audio signal by the second device when the payload received contains errors.

4. The method of claim 1, in which the step of transmitting the data packet is comprised of the substep of repeatedly retransmitting the data packet by the first device unless and until an acknowledge signal is received from the second device indicating the audio signal has been received without error, or the asynchronous connectionless link is flushed.

5. The method of claim 1, in which the data packet is further comprised of information indicative of the technique with which the first portion of encoded audio signal is encoded.

6. The method of claim 1, in which the data packet is further comprised of an auxiliary data field containing information that is not representative of an audio signal.

7. The method of claim 6, in which the auxiliary data field contains telephone caller identification information.

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INVESTOR IN PEOPLE

Application No: GB 0314168.6
Claims searched: 1-7

Examiner: Adam Tucker
Date of search: 8 July 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A, P	-	WO 01/52466 A1 (Nokia) See whole document in particular page 4 line 30-page 5 line 6, page 6 lines 8-9 and claim 16
A, P	-	GB 2363944 A (Ericsson) See whole document
A, P	-	WO 01/97385 A2 (Ericsson) See in particular the summary of the invention
A	-	http://www.sysopt.com/articles/bluetooth/index2.html , "Bluetooth technology and implications" 14 December 1999, Heidi Monson
A	-	http://www.cs.uno.edu/~golden/6990MC/MobilePapers/bluetooth.pdf , "Bluetooth: Vision, Goals and Architecture, Haartsen et al., 27/08/1998, See in particular sections E, G & H
A	-	http://www.pday.com.cn/technology/bluetooth_documents/BaseBand.pdf , "Bluetooth Specification version 1.0A", 24/07/1999, See in particular pages 60, 68, 71, 72, 82, 83

Categories:

X Document indicating lack of novelty or inventive step	A Document indicating technological background and/or state of the art.
Y Document indicating lack of inventive step if combined with one or more other documents of same category.	P Document published on or after the declared priority date but before the filing date of this invention.
& Member of the same patent family	E Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO, & US patent documents classified in the following areas of the UKC^v:

H4L, H4P

Worldwide search of patent documents classified in the following areas of the IPC⁷ :

H04B, H04L, H04M, H04Q

The following online and other databases have been used in the preparation of this search report :

WPI, EPODOC, PAJ, INSPEC and selected internet sites

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